Dual-Beam Interferometer Development and Validation

Stephen Frasier
Electrical & Computer Engineering
Knowles Engineering Bldg., Rm. 215
University of Massachusetts
Amherst, MA 01003
phone: (413) 545-4582 fax: (413) 545-4652 email: frasier@ecs.umass.edu

Grant Number: N00014-98-1-0612
http://www.umass.edu/mirsl

LONG-TERM GOALS

My long-term goal is to contribute to our understanding of the upper ocean and lower atmosphere through the development and application of microwave, acoustic, and optical remote sensing techniques.

OBJECTIVES

The objective of this effort is to develop an instrument and techniques to estimate surface current vectors from aircraft using along-track interferometry.

APPROACH

A low-cost dual-beam interferometric radar termed the Dual-Beam Interferometer (Frasier & Camps, 2001) has been designed and constructed. The radar is an along-track interferometric SAR producing two beams, one squinted forward and one squinted aft. The two interferometer beams yield two components of the surface Doppler velocity from which surface current is estimated. The instrument has been packaged into a wing-mounted pod suitable for mounting on NOAA WP-3D research aircraft, or other aircraft with compatible mounting pylons. Figure 1 shows the top of the pod and the chassis mounted under the aircraft wing. The two forward looking antennas (white rectangles) can clearly be seen at the front and the read of the instrument chassis. These are separated by approximately 1 meter which provides the along-track interferometric baseline. The aft looking antennas can also be seen on either side of the chassis above the forward looking ones. The instrument electronics is packaged into the cube between the antennas. The bottom of the pod (the shell) is not shown.

WORK COMPLETED

With aircraft flight support from collaborators at NRL (M. Sletten), initial flight tests of the DBI instrument were conducted at the NOAA Aircraft Operations Center in Tampa, FL in December 2002. While the test flights were largely successful, some overheating within the pod caused on set of radar receivers to fail. As a result, no interferometric measurements were possible although dual-look (foreward, aft) imagery were obtained.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2003**	2. REPORT TYPE	3. DATES COVERED **00-00-2003 to 00-00-2003**

4. TITLE AND SUBTITLE **Dual-Beam Interferometer Development and Validation**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Electrical & Computer Engineering,Knowles Engineering Bldg., Rm. 215,,University of Massachusetts,Amherst,,MA, 01003**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
My long-term goal is to contribute to our understanding of the upper ocean and lower atmosphere through the development and application of microwave, acoustic, and optical remote sensing techniques.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Following the initial flights, modifications to the pod were made to improve airflow and cooling by installing a NACA vent. A second set of test flights were conducted in August 2003 just prior to hurricane flights by the NOAA aircraft. These flights were conducted over an HF "WERA" current mapping radar system operated by the University of Miami. It appears that good quality interferometric data were acquired, and the availability of the HF observations will provide an excellent source for comparison. Analysis of these data is commencing.

RESULTS

Figure 2 shows a transect across Charlotte Harbor, just south of Port Charlotte and WNW of Ft. Myers, FL. Both forward and aft beams are shown from the forward set of antennas. The swath width is approximately 7 km resolved with moderate resolution of 17 m in range. The swath corresponds to large incidence angles between $65°$ and $85°$. Light surface winds of approximately 3-4 m/s were reported during the flights. Given these low winds, flight altitude was chosen to be approximately 600 m to enable large incidence angle measurements and reasonable signal to noise ratio.

These images were focused using an adaptation of the extended chirp scaling algorithm (moreira, et al 1994) implemented by the Naval Research Laboratory. In these images, range and azimuth resolution are approximately matched with 66 independent looks. As a result of the large number of looks, very little speckle is evident in the imagery.

Sinuous surface slick features are observable over much of the water surface within the bay. Such features are commonly observable under light wind conditions and are attributed to biological sources. Where present, the surface film modifies the surface tension of the water, suppressing the Bragg-resonant capillary waves that are responsible for the microwave echo. Thus, slicks appear as dark regions in the imagery and indicate locations of surface current convergence where the slick material accumulates. Under stronger wind forcing, slicks tend to be broken up by the mechanical action of larger gravity waves.

IMPACT/APPLICATIONS

Along-track interferometric SARs commonly provide a single component of surface Doppler velocity. The ability to obtain surface velocity *vector* estimates in a single aircraft pass would permit long distance strip mapping of waves and current vectors in coastal regions and offshore. Other studies including air-sea interaction, signatures of internal waves, and wind vector scatterometry are also possible.

TRANSITIONS

None.

RELATED PROJECTS

We are also investigating the utility of imaging Doppler radar for use in estimating currents and wave heights within and just beyond the surf zone.

Figure 1: DBI instrument frame and pod top mounted on the NOAA WP-3D wing (pod shell not shown).

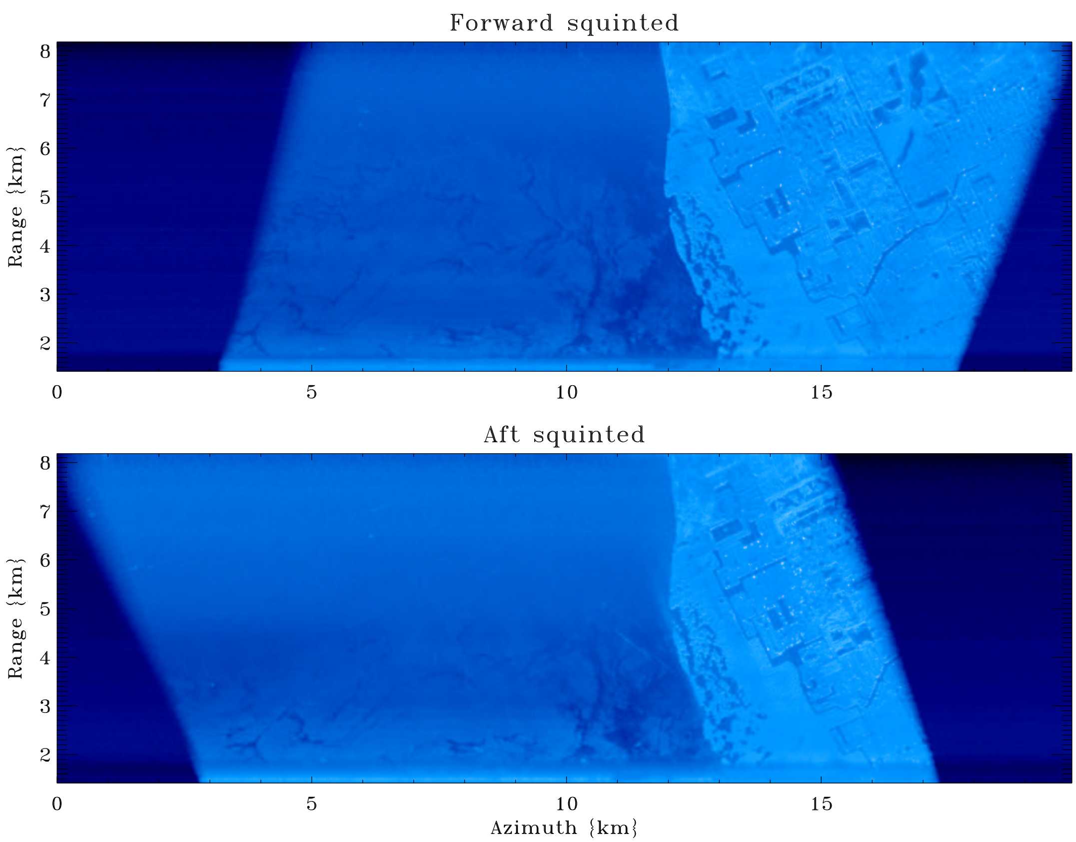

Figure 2: Fore (top) and aft (bottom) views of surface slicks on Charlotte Harbor. Approximately 20 dB difference between average land and sea surface echoes.

REFERENCES

Frasier, S.J., and A.J. Camps, 2001: "Dual-Beam Interferometry for Ocean Surface Current Vector Mapping", *IEEE Trans. Geosci. & Rem. Sensing*, **39**(2), 401–414.